

# Operational Capabilities of the SFOF Mark IIIA User Terminal and Display Subsystem

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*The Space Flight Operations Facility (SFOF) Mark IIIA Central Processing System has been developed to meet requirements for independent and simultaneous operation of multiple missions flown by an array of increasingly complex and sophisticated spacecraft. The Deep Space Network (DSN) Operations and Mission Support Areas must all be supported by the same computer system and therefore have been equipped with identical user input/output devices. The user input/output devices and their capabilities are described with the suggestion that operating techniques be developed and adapted to the improved and more interactive input/output capabilities of the new User Terminal and Display Subsystem.*

## I. Introduction

The SFOF Mark IIIA Central Processing System (CPS) was developed at JPL to meet the requirements of the DSN and the flight projects it supports. The System Functional Design, 360/75 Computer Configuration, User Device Switching, and Video Image Display were discussed by Willems (Ref. 1), Stiver (Ref. 2), Simon (Ref. 3), Habbal (Ref. 4), and Diem (Ref. 5).

The Digital Television Assembly, Video Image Display Assembly, Simulation Center, Diagnostics, and High-Speed Data Processing were discussed by Singleton (Ref. 6), Volkoff (Ref. 7), Polansky (Ref. 8), Wells (Ref. 9), Mullen (Ref. 10), and McClure (Ref. 11).

## II. Subsystem Configuration and Interfaces

The User Terminals and Display Devices of the User Terminal Display Subsystem (UTDS), represented by the column of blocks along the lefthand side of Fig. 1, provide

the primary interfaces between the user/controllers and the DSN Mark III Data System and its facilities and subsystems.

Figure 1 is a simplified hardware block diagram of the UTDS. The interfaces between its assemblies are shown as well as the interfaces with the Scientific Computing Facility, and the mission-dependent Mission and Test Video Subsystem. By matching the lines along the right-hand side with Figs. 2 and 3, the interfaces with the Mark III CPS can be seen. Figure 4 illustrates the CPS interface with the remainder of the DSN Mark III Data System (GCF and DSIF). Figure 5 illustrates the major hardware/software interfaces at the SFOF.

## III. UTDS Hardware Description

User terminal and display devices may be divided into two categories. The first category includes those devices which directly control or are controlled by elements of the SFOF CPS. The second category includes user

devices located in the user areas but controlled or driven by elements of other facilities or systems.

#### **A. The First Category of User Devices**

**1. Display Station IBM 2260.** This device consists of a cathode-ray tube (CRT) output display and may be equipped with a manual entry keyboard. When equipped with a keyboard, it is designated 2260 WK and when without the keyboard as 2260 WO. Both configurations are commonly referred to as 2260. Manual entry device (MED) requests are entered via the keyboard in fixed field format. The entries are displayed, character by character, as they are entered via the keyboard. By entering the @ character at any point in the MED entry, a display will appear to provide the options available for use in formulating the entry. Administrative messages and alarms functionally related to each MED may also be displayed.

The formats are segregated by subsystem and provide the capability for performing a comprehensive set of functions. The MEDs acceptable from each station are controlled by functional commitment.

The 2260 WO may be provided as an independent display device in which case its displays are determined by its scheduled allocation as an output display, or it may be provided as an adjunct to a 2260 WK, in which case its displays are controlled by local MED inputs.

**2. Card Reader IBM 2501.** This device provides for rapid input of MED instructions, for input of user data in response to program requests and to enter JPL OS/360 background or job-shop jobs under certain conditions.

Well-planned use of the 2501 can greatly simplify the input/output (I/O) operation. The Simulated Manual Input Messages (SMIM) program can, to some extent, automate the entry of multiple MED instructions and thus reduce the load on the 2260 WK. The use of user data decks in response to program requests augments the interactivity between the user and the software subsystems. The JPLOS/360 JOB capability makes the 360/75 computer available for independent program operation.

**3. Line Printer IBM 1443.** This device is a 240-line per minute printer provided as an output medium for data from the 360/75 computer. Data may be directed to these printers from the user area manual entry devices or by allocating the device in the Data Processing Control Center (DPCC) as an output writer.

The 1443 is not intended as a bulk printer or logging device but as a medium for receiving alarms, status messages, administrative messages and reports. It is most useful as an adjunct to the digital television display.

**4. Format Request Box (FRB).** The format request box provides the user with the capability of selecting one of a set of fixed formats for display on a designated channel of the Digital Television Assembly (DTV). This assembly initially provides 60 DTV channels which display data processed and formatted by the 360/75.

The format request is made by entering on six thumb-wheels the data ID, format number, and the channel on which the display is desired. A momentary contact push-button indicator on the box enters the request into the system. Its acceptance by the system is acknowledged by relighting of the enter button.

The use of the FRB expands the channel display capacity; however, because the DTV channel is available to many users, their requirements must be considered when changing formats.

**5. DTV Hard Copy Printers Gould 4800.** The DTV hard copy printer provides the user with a permanent record of the image displayed on the digital television monitors. The hardcopy output capability consists of six printers, each of which outputs a 20.3- × 15.2-cm (8- × 6-in.) printed replica of a selected DTV channel's alphanumeric and/or graphic volatile display. Selection is accomplished via one of six copy request units, each of which can select any of the sixty DTV channels for printout on that panel's associated printer. Hardcopy prints are available in about eleven seconds unless that printer is busy servicing prior requests. Requests are queued in the 3100 computer, which inhibits updates to any DTV channel that has hardcopy requests pending. This ensures that the display content at the time of selection will not change before a copy is stored in the Display Image Buffer (DIB) for subsequent printing. The DIB provides simultaneous storage for only one printout at each printer. Therefore, multiple requests at a single printer will delay channel updates, for a multiple of 11 seconds. However, requests from several printers can be processed in an overlap mode.

This capability will be extremely useful for copying plots, or graphic displays. The copy is reproducible on most copiers and is fully storable itself. The device is not useful as a bulk printer but is ideally suited for recording a significant event for more detailed study by recall from system data records.

The printers will be located in various user and operations areas and are user operated with the printer controls and the DTV copy request unit.

**6. Digital Television Copy Request Unit—JPL CRU.** This device is separately provided to enable channel selection for the DTV hard copy printer. It contains one 12-position and one 10-position thumbwheel and a momentary contact push button indicator. The thumbwheels permit 129 channel selections. The request is entered into the display computer by pressing the push button which extinguishes the ready light. Acceptance of the request is acknowledged by relighting of the ready light.

**7. Time Reference Displays.** Time reference displays are included in the Mission Display Board (MDB), on SFOF Internal Comm Subsystem (SIC), TVSA monitors, and as ceiling-mounted readouts in the user areas.

The MDB timed displays are controlled from the support chiefs' console and may display time referenced to significant mission events or to the localities of the Deep Space Stations. These time displays are also available on TVSA channels for general or local display.

Event counters driven by the time reference system are also available. These displays are ceiling-mounted and controllable by the user from console- or desk-mounted panels for countup or countdown.

**8. Video Image Display (VID) Photo Printers.** Initially, two printers will be provided in the user area in order to provide high-quality operational prints of spacecraft-acquired image and image-related data and histogram plots. Additional printers, up to a total of 32, may be added to the assembly as future requirements dictate. Each will be a self-service unit capable of printing images from any VID display channel.

The output will be 20.3- × 20.3-cm (8- × 8-in.) semi-archival positive opaque prints with a resolution of 1536 × 1536 elements in 32 discernible shades of gray.

**9. High-Resolution VID Monitors.** High-resolution display of the spacecraft pictures on 43.2-cm (17-in.) TV monitors will enable the experiment and science teams to make real-time decisions based on the spacecraft pictures. The high-resolution monitors will display 832 elements per line and 800 lines. They will provide 32 discernible shades of gray with equal resolution of shades over the dynamic range. Six bits per pixel image data will be

converted to 64-level video to eliminate quantization contouring. In addition to the image, a 16-shade reference gray-scale will be displayed to the right of the image. Geometric error will be held to 2%. Dynamic focus and gamma correction will be provided. To provide maximum picture definition, digital signals will be fed to the monitors; the conversion to analog video will be performed at each individual monitor. The VID will be capable of updating the entire display in 5 seconds. The basic VID assembly will include two high-resolution channels with capability for expansion to eight channels.

## **B. The Second Category of User Devices**

**1. Teletype Printers—Teletype Corp RO Teletypewriter Set (TTY or RO).** These devices are provided in two configurations. The normal sets are furnished for the receipt and display of message traffic from the NASCOM network via the West Coast Switching Center. These messages are processed in accordance with NASCOM procedures.

Identical devices are furnished for CPS data printout. These machines have an added 36-button selector box which enables them to be connected to one of 36 teletype distribution channels. They may also be equipped with a different character set depending upon the coding of the data to be displayed.

The CPS data destined for the latter machines is transferred by electrical interface to the GCF SFOF Comm Terminal Subsystem at the rate of 40.8 kilobits per second for storage until it can be switched by the Communications Processor (CP) and transmitted to the teletypewriter sets.

It is important to consider the fact that the maximum printing speed of the RO sets is 100 words per minute or 50 data bits per second. This is a ratio of 816:1, which limits the rate at which the CP can accept data from the CPS for display over a given TTY channel. The switching functions in the CP and the carriage returns and line feeds performed by the printer subtract further from the nominal machine speed of 50 data bits per second. In effect, the output rate of the teletypewriter limits the output rate of the 360/75 to something less than 50 bits per second. Any attempt to output data to the teletypewriters in excess of these speeds will cause a loss of data in the CP due to drum wraparound, a closure of the CPS-CP interface, and a resultant backup of data in the Computation and Storage Subsystem.

**2. Television Assembly (TVSA) Monitors.** Approximately 400 television monitors, of various types for different purposes, are located throughout the SFOF. Operations consoles are equipped with 23- or 36-cm (9- or 14-in.) monitors with selector keys that permit the user to select available video inputs. Ceiling- and floor-mounted, 58-cm (23-in.) monitors are normally patched to a single preselected camera. It is possible, however, to change the camera to which the 58-cm (23-in.) monitors are patched by making the proper interconnections in the centralized control equipment. Free-standing monitors, either 43- or 28-cm (17- or 11-in.), are installed on tables where close viewing is possible. Selector keys are provided for the 43- or 28-cm (17- and 11-in.) monitors to permit the user to select available video inputs.

The television communications equipment (see Fig. 6) acquires information for display in the following manner:

- (1) Surveillance television cameras are mounted in various parts of the SFOF in such a manner as to permit television monitoring of these areas.
- (2) A group of television cameras is mounted in a manner that will permit television monitoring of both incoming and outgoing teletype traffic.
- (3) Hard copy television cameras are located in various parts of the SFOF and are arranged to permit viewing of status boards, chart recorders, time displays, and handwritten, typed, or other graphical hard copy material.
- (4) Data from non-camera sources such as computers are provided as a video signal to a patching assembly which makes it available to test and monitoring equipment, to fixed monitors, and to the solid-state video switching assembly, which makes it available to users by push-button selection.

Digital television display is one of the most significant additions to the SFOF capabilities. It provides the user with real-time display of processed data formatted to his specifications and updated nominally every 4 seconds. Alarm, range and status indicators can be included.

Alphanumeric and graphic representation may be used separately or in combination to provide a wide variety of annotated plots and graphs.

**3. Scientific Computing Facility (SCF) I/O Devices.** SCF I/O devices perform the same relative functions for users of the 1108 computers as the CPS devices do for their users.

The CPS and SCF computers have tape and electrical interfaces for the purposes of transferring data and files common to programs in both computers. The interconnection of I/O devices or transfer of display data between the two systems is not contemplated.

## IV. Conclusion

The Mark IIIA User Terminal and Display Subsystem and related user devices provide greatly increased capabilities for interactive control of data processing functions by mission operations and DSN operations controllers.

For the first time both the users and the controllers of the Central Processing System have a direct hands-on capability without intervention of operators. The CPS systems controllers, DSN operations controllers, and the MOS controllers of the various projects use identical I/O hardware and operating techniques.

The common operating techniques combined with the JPLOS/MCUI capability of handling mission peculiar data as modules of a single system provide a highly versatile multi-mission capability.

At this time the system is in full time use, with exceptions, and is in transition from development to operational status. It is being closely evaluated by the *Mariner* Mars 1971 MOS team, by the *Pioneer* operations planning group, and by the DSN Operations Control Team in preparation for support of the *Mariner* Mars 1971 and *Pioneer F* and *G* interplanetary flight projects.

It has already become evident that operating philosophies and efficiencies can be significantly improved by adapting to the improved system capabilities.

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# USER TERMINAL AND DISPLAY SUBSYSTEM

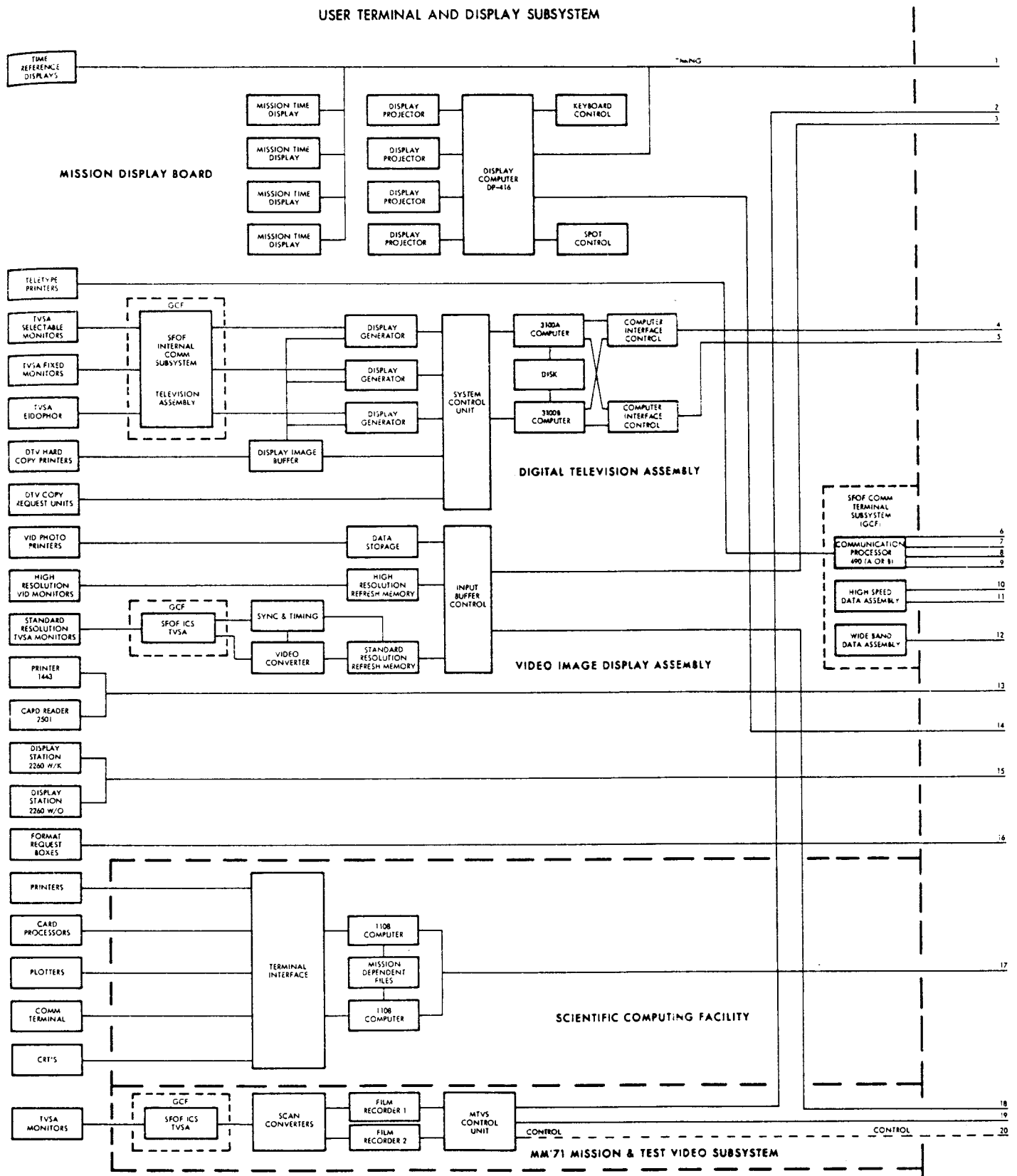
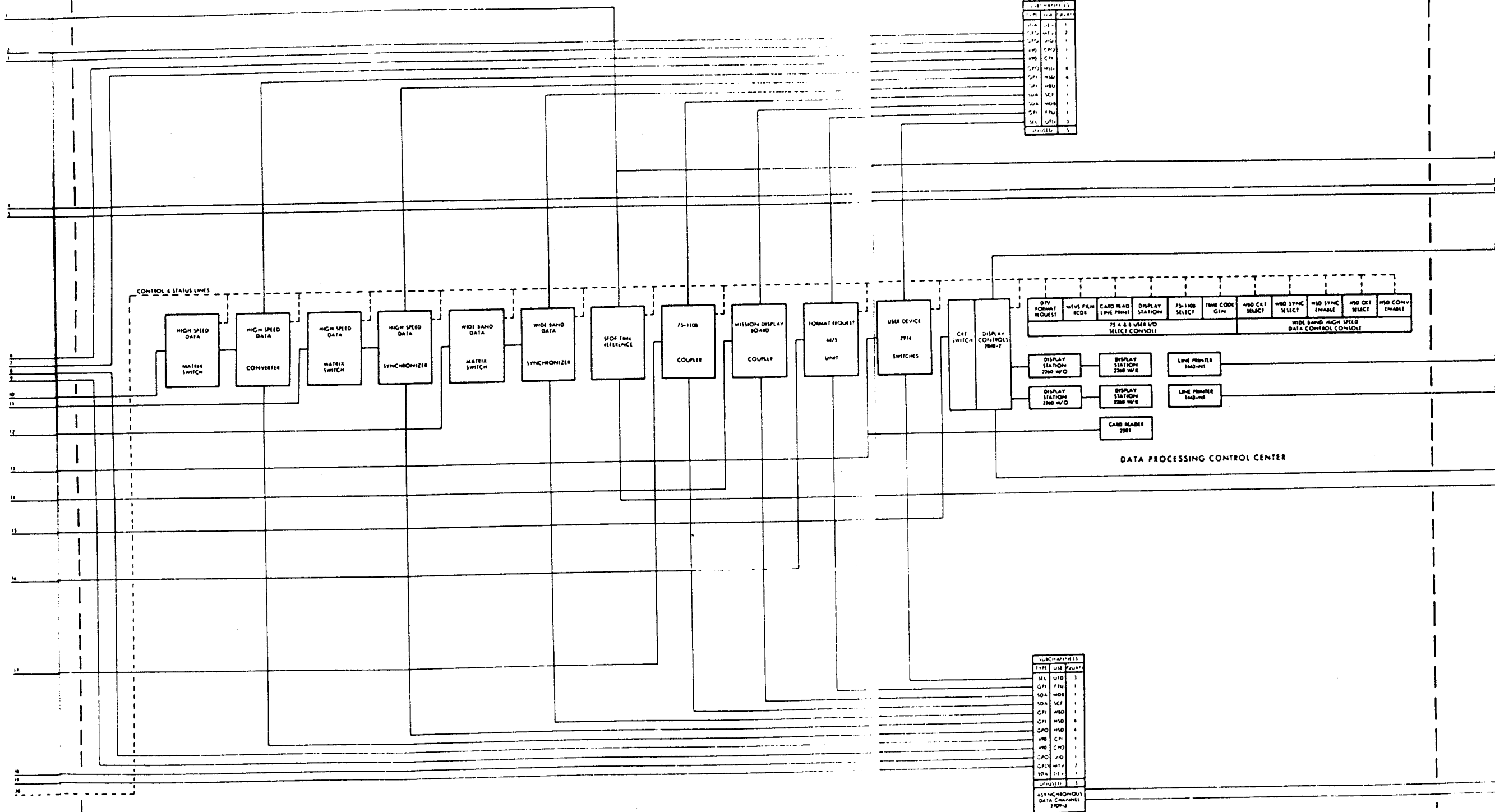


Fig. 1. User terminal and display subsystem

[illegible]

SUBCARRIER		
TYPE	USE	VALUE
SL	UTO	1
GPI	FRU	1
SDA	WOB	1
SDA	SCF	1
GPI	WBO	1
GPI	HSD	0
GPO	HSD	0
WBO	CP1	1
WBO	CPO	1
GPO	VIO	1
GPO	MTV	2
SDA	LEV	1
UNUSABLE		1

ASYNCHRONOUS  
DATA CHANNEL  
7000-J

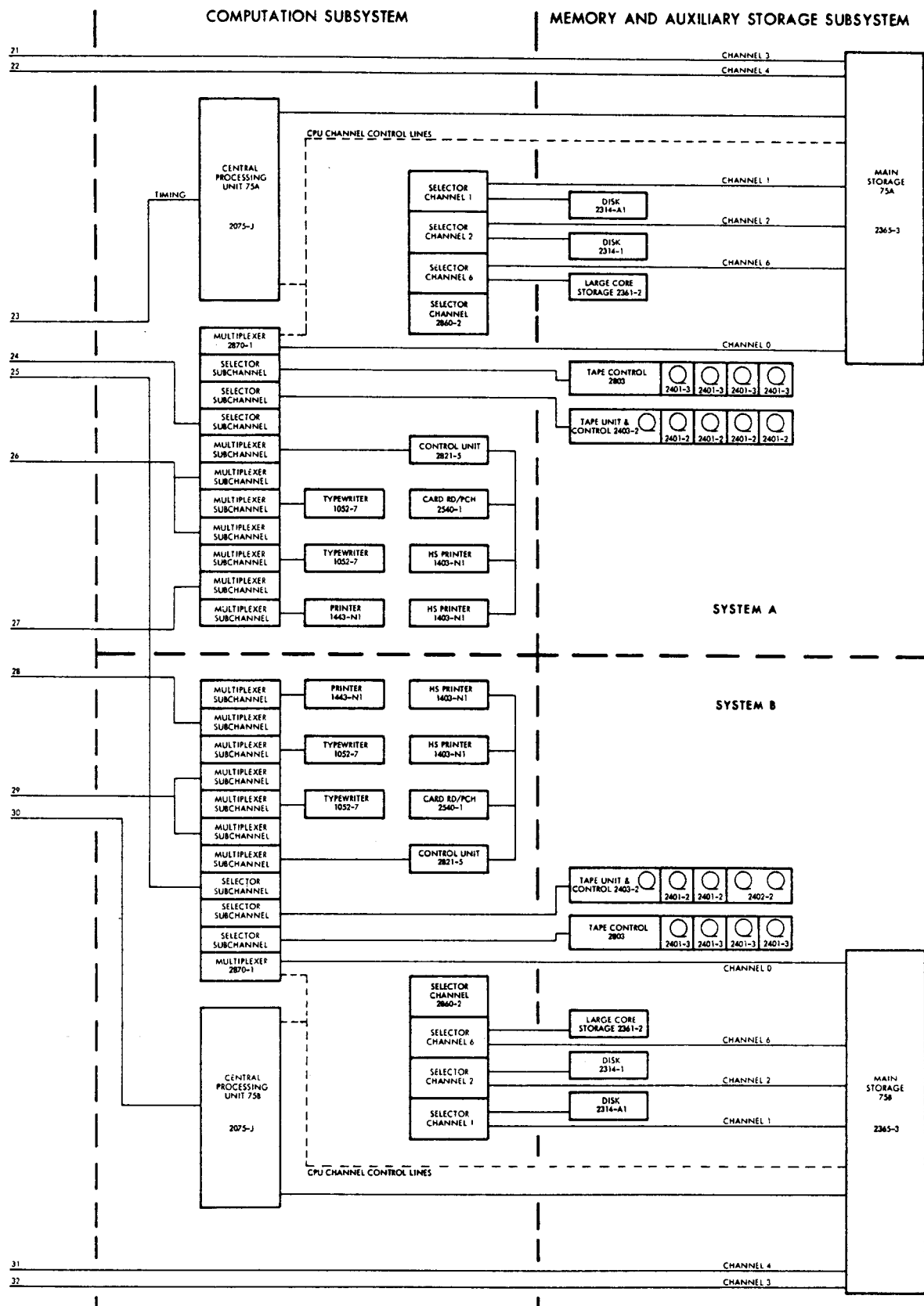
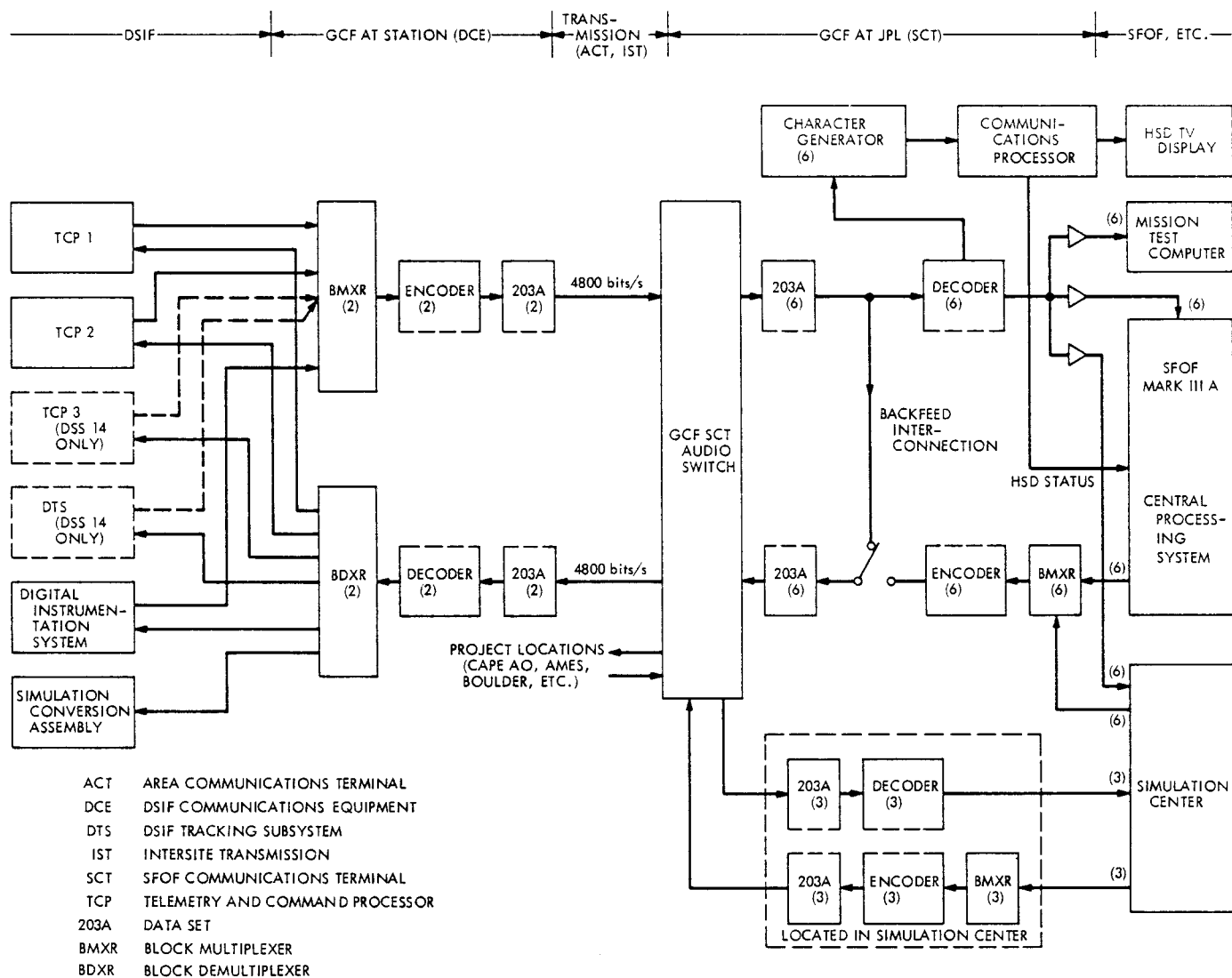
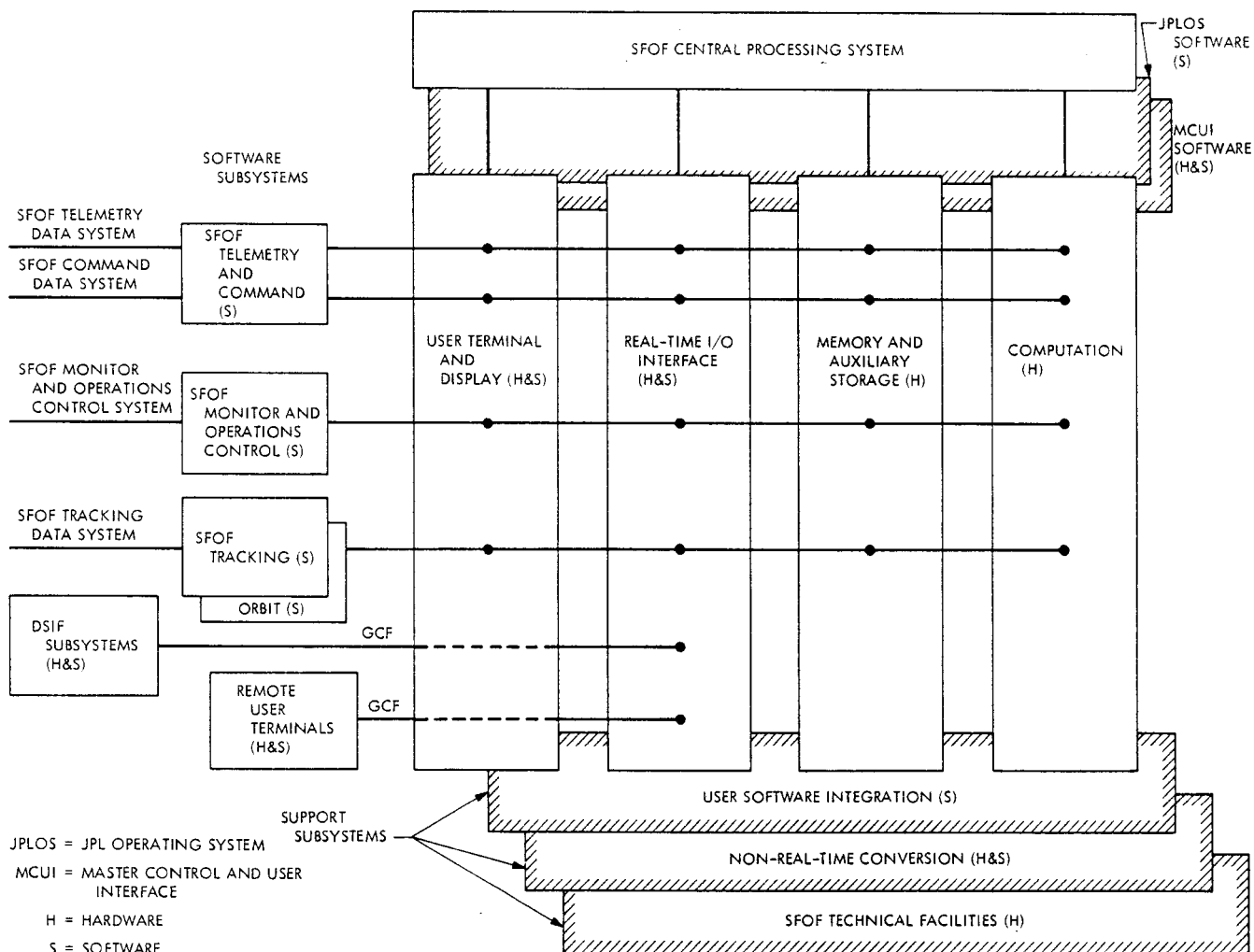


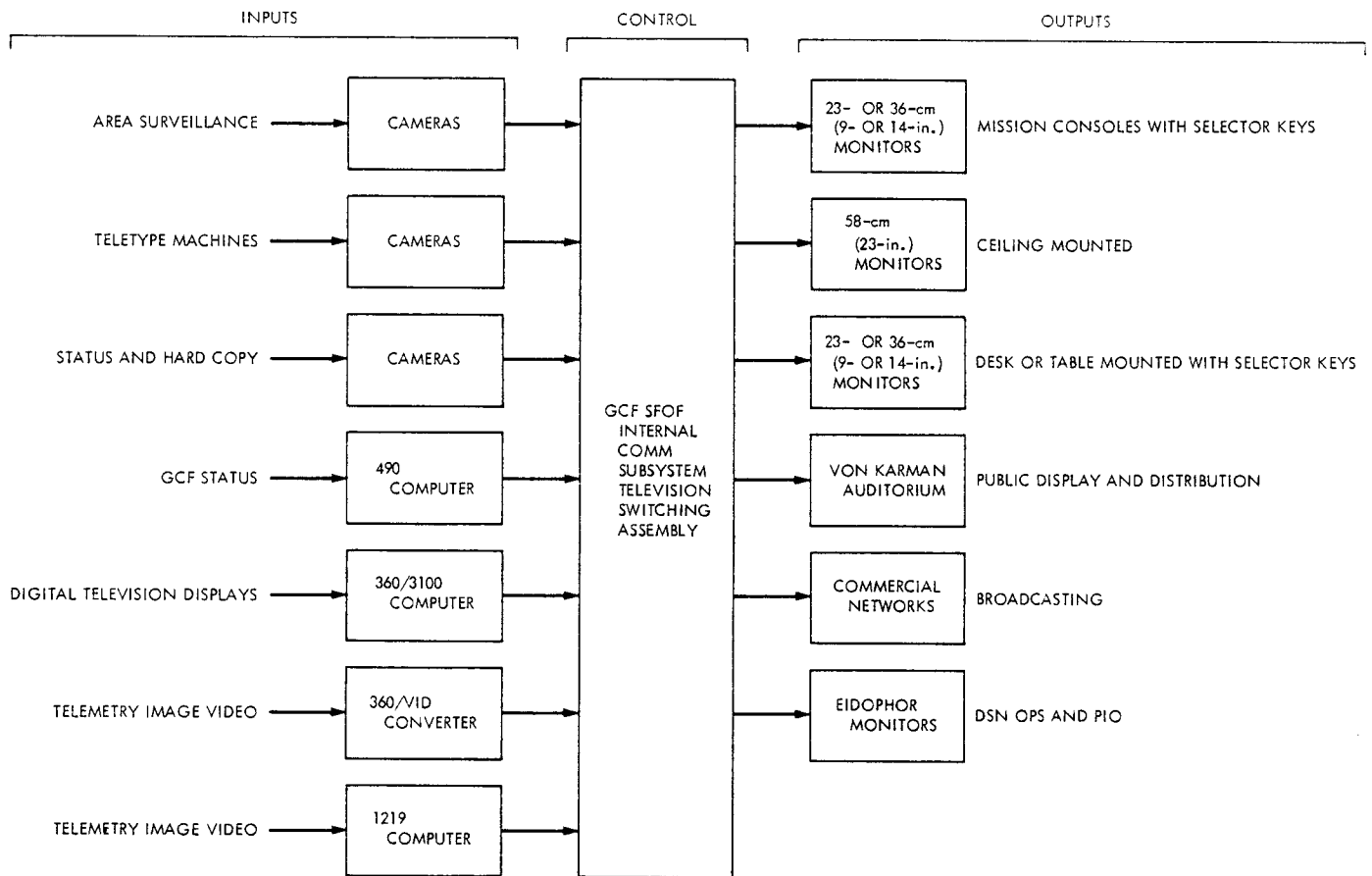
Fig. 3. Computation and memory and auxiliary storage subsystems



**Fig. 4. Ground Communications Facility 1971-1972 High-Speed Data System**



**Fig. 5. SFOF Central Processing System hardware/software interfaces**



**Fig. 6. GCF SFOF television system configuration**